Defense Technical Information Center
Compilation Part Notice

ADP010874

TITLE: Principles and Application of Geographic
Information Systems and Internet/Intranet
Technology

DISTRIBUTION: Approved for public release, distribution unlimited

This paper is part of the following report:

TITLE: New Information Processing Techniques for
Military Systems [les Nouvelles techniques de
traitement de l'information pour les systemes
militaires]

To order the complete compilation report, use: ADA391919

The component part is provided here to allow users access to individually authored sections
of proceedings, annals, symposia, ect. However, the component should be considered within
the context of the overall compilation report and not as a stand-alone technical report.

The following component part numbers comprise the compilation report:
ADP010865 thru ADP010894

Principles and Application of Geographic Information Systems and Internet/Intranet Technology

Prof. Dr.-Ing. Wolfgang Reinhardt
Wolfgang.Reinhardt@unibw-muenchen.de
http://agis.bauv.unibw-muenchen.de/staff/reinhardt/home.htm

University of the Federal Armed Forces Munich
Institute for Geo Information and Land Development
Werner-Heisenberg-Weg 39
D-85577Neubiberg
Germany

key words: GIS, Internet/Intranet

Abstract

The paper presented consists of three main parts. In the first part we roughly outline the state of the art of Geographic Information Systems (GIS) mainly with respect to technology and data. Within this part we also give some examples where GIS is applied in military applications.

The second part gives an overview of architectures and some technical aspects of GIS-Internet/Intranet solutions, compares the different approaches and discusses the potential of this technology in general. Furthermore some examples demonstrate the practical use of GIS and Internet/Intranet. As the World Wide Web (WWW) gains more and more significance and there is a large demand of GIS applications in the Internet/Intranet we introduce the main principles of this technology. Especially we explain how Geographic Information Systems can be connected to the world wide web and which extensions are necessary to transfer and to view Geographic data. In this part we also show how the Virtual Reality Modelling Language (VRML) can be used in this field. Part of this is based on results of some projects conducted for the AMilGeo (Amt für Militärisches Geowesen) of the German Federal Armed Forces as well as on other civilian projects.

In the third part of the paper we demonstrate the potential of the GIS and Internet/Intranet technology for civilian and military applications. Besides we discuss the main advantages of GIS and Internet/Intranet, such as Ease of Use or the possibility to access up-to-date information in various databases. Furthermore we show how the connection of Internet and telecommunication can be used in GIS.

1   State of the art of Geographic Information Systems

Geographic Information Systems are Information Systems which are extended to handle geographic data which often also is called spatial data. That means a GIS in addition to the common IS functionality offers specific data types, data access methods and spatial data analysis methods.

Due to the fact that more than 80% of all data are somehow related to a geographical position GIS is used in very many fields today, civilian and military too.

Geographic Information Systems consist of hardware, software and data. As hardware platform today standard PCs are used. GIS software packages are offered from more than 500 companies world-wide, but about ten of the most important vendors share more than 60% of the market. Data is not only the most important part of a GIS but also the most costly factor. This is due to the generally high costs of data

acquisition. Figure 1 depicts the approximately cost relation of hardware, software and data which has been verified in various projects.

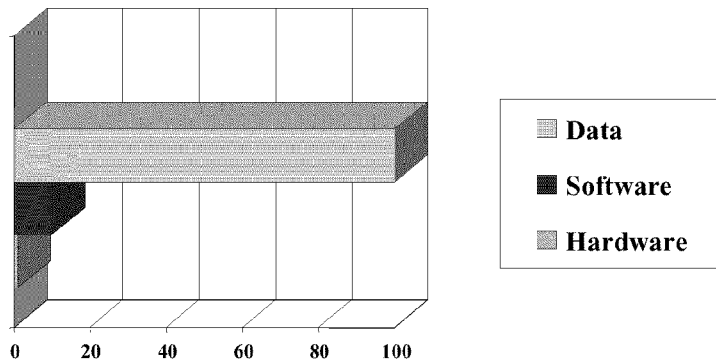These days GIS data is available in many countries, often countrywide and in various forms.

Figure 1: Cost relation of hardware, software and data in a GIS

1.1   Technology and trends

From a technical point of view we can state that state of the art GIS hardware and software are standard IT products. Some of the important points:

- GIS support the client / server architecture. Often in a GIS a standard data base is included. These data bases are mostly relational data bases. Object oriented data bases are used very seldom
- The programming languages used are mainly C++ or Java, for customising purposes also Visual Basic
- Internet/Intranet technology has become a key factor in GIS during the last years (for details see chapter 2). This technology enables the introduction of GIS based services which can be used in Intranets and in the Internet. For these services recently also eCommerce techniques and products have been utilised.
- Based on the connection of Internet and telecommunication new services have been introduced which can be used in principal from mobile phones and other mobile equipment ('mCommerce applications'). Mainly so called location based services are discussed widely nowadays. These services e.g. allow for queries to show the way to a point of interest (see figure 2)

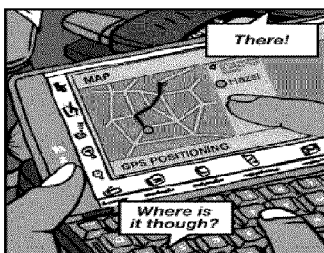More information to these items are given in the contributions in [Reinhardt, 2000]

Figure 2: Example of a location based service

1.2   Interoperability

As already mentioned there is a large number of data sets available in most countries of the world. These data sets are available mainly on state, county or community level as well as on enterprise level.

These GIS in general have been designed in a proprietary manner based on proprietary systems. Due to this fact data exchange or integration without loosing information is not easy. For this reason several activities have been started during the last decade which are aiming on an improvement of this situation. The most remarkable activities – from the point of view of the author – are the activities of the

- International Standardisation Organisation (ISO), TC 211 [http://www.statkart.no/isotc211/] and the
- Open GIS Consortium (OGC) [http://www.opengis.org]

The activities of the OGC are consequently following the idea of interoperability of geographic information. OGC and ISO are working together very closely ('first class liaison'). E.g. OGC uses ISO specifications (international standards, draft international standards) within their development process to produce implementation specifications.

Because of the strong impact of OGC work on GIS in general it shall be outlined roughly:

The Open GIS Consortium has been founded as a non profit organisation in 1994 in the US. The consortium now has more than 200 members. All relevant computer hardware, data base and GIS vendors as well as other IT companies, consulting companies, GIS data providers and users from all over the world are working in OGC. The aim is to allow for a interoperability of GIS data without any loss of information. For that goal abstract and implementation specifications are produced in working groups which are in general implemented by the vendors within their GIS software. OGC´s work of the last two years is strongly focused on the use of internet technology.

Roughly speaking the idea of interoperability can be reached in two ways:

- By direct access to distributed data bases (on-line) over common networks. For this purpose standard access methods are defined which are published on OGC´s homepage.
- By means of file transfers (off-line). For this purpose standard data description languages are defined and used respectively. With these languages data schemes and the data itself can be described. The file can be transferred via networks like the internet, of course.

The approach of the second way is outlined now shortly:

In this approach GIS features are described in a specific language, the OpenGIS Geography Markup Language (GML). This GML is based on the well known XML language of the w3 consortium [http://www.w3.org/]. More information on GML can be found at [https://feature.opengis.org/rfc11/GMLRFCV1_0.html]

With this approach the geographic data is transferred in ASCI files. The representation of a point is like the following:

```
<?xml version="1.0" standalone="yes" ?>
<!DOCTYPE Point (View Source for full doctype...)>
- <Point name="location" srsName="epsg:3567">
<CList>445.12,345.71</CList>
</Point>
```

For a graphical display in a standard browser one of the common graphics formats can be used, these are:

SVG (Scalable Vector Graphics, http://www.w3.org/Graphics/SVG/Overview.htm8)
VML (Vector Graphics Markup Language, http://www.w3.org/TR/NOTE-VML)
VRML (Virtual Reality Markup Language http://www.vrml.org/)
PNG (portable network graphic http://www.libpng.org/pub/png/)

If a GIS data server is able to deliver data in this GML format and a converter to one of the graphics formats mentioned is available the data of the server can be accessed from a client using a standard browser.

2   Geographic Information Systems and Internet Technology

2.1   Some remarks on web technology

Webbrowsers, like Netscape Communicator or Microsoft Internet Explorer, can nowadays be referred as standard equipment of a PC. With an appropriate network authorisation it is possible to connect to the WWW with a webbrowser, either by clicking on a link in an HTML[*] (Hypertext Markup Language) page or by typing a Uniform Resource Locator[**] (URL). The request is transferred to the addressed webserver through the Hypertext Transfer Protocol (HTTP Protocol). The according HTML-page is invoked on the server and transferred to the webbrowser where it is displayed. A detailed description of the WWW functionality is presented in (Assfalg et al., 1998).

The following sections present and discuss briefly different possibilities to link GIS to the WWW. These solutions run partly on the server and partly on the client side. The webbrowser is considered as a client, which sends requests to the webserver. First we present solutions particularly based on the server side and then on the client side.

2.2   GIS linkage to the WWW

Web applications in general follow a so called 3tier architecture. In our case we have a Geo data server a web or internet server and a web or internet client (browser) as depicted in figure 3.
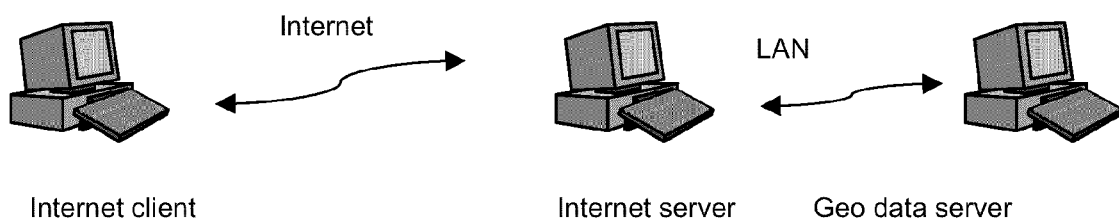

Internet client   Internet server   Geo data server

Figure 3: 3 tier architecture

Figure 4 now shows schematically the communication between webbrowser, webserver and GIS server. On the webserver side there are basically five possibilities to realise the GIS-connection to the World Wide Web: Common Gateway Interface (CGI), Webserver Application Programming Interface (API), Active Server Pages (ASP), Java Server Pages (JSP) and Java-Servlets. The user on the client side does not need knowledge about the linkage of the IMS at the server side, but the system administrator respectively application developer should be familiar with these techniques.

Figure 4. GIS linkage to the WWW
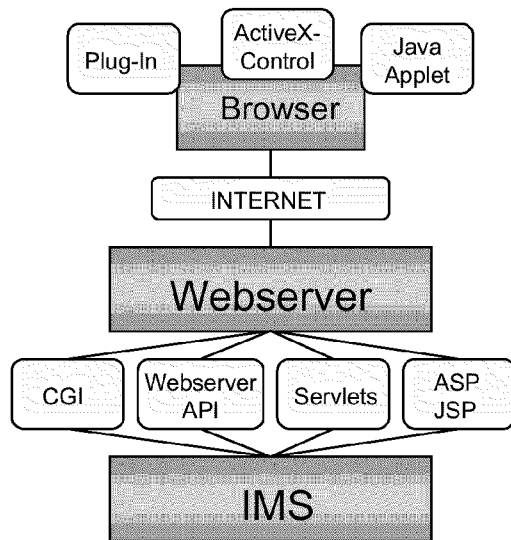
For a detailed discussion of these techniques please refer to [Reinhardt and Leukert, 2000]

On the client side: In general a webbrowser can handle HTML-documents and embedded raster images in the standard formats GIF, JPEG or PNG. To deal with other data formats like vector data, video clips or music files the browser's functionality has to be extended. This can be done by using e.g. plug-ins, activeX controls or Java applets. For a description of these techniques also refer to [Reinhardt and Leukert, 2000]

2.3   Type of transferred geo data

A decisive question for using GIS in the Internet is the form of data (vector or raster) which is used to transfer the data to the client. In principle it is possible to use raster as well as vector data. It should be mentioned that the transfer format is independent from the format the data is stored on the server. In most applications geo data is stored as structured objects in form of vector data in a proprietary format. For the data transmission to the client the map is converted in raster or a suitable vector format.

When raster data is transferred a standard webbrowser without extension can be used since webbrowsers can display GIF and JPEG. Only a kind of screenshot in form of a raster image is send to the client. That means the data on the server has to be converted to a raster format. The data volume is due to the known image size of X * Y pixels estimable and the original data on the server is safe as only an image is sent to the client. A disadvantage of using raster data is the lack of comfort of handling. Single objects cannot be highlighted by moving over them with the mouse. In addition a server contact is necessary per each request from the client but with a high performance infrastructure, e.g. Intranet, that does not cause problems.

Vector data can handled only in a standard webbrowser with extended functionality (e.g. plug-in). The user gets a more comfortable handling with vector data. For example single objects can be selected directly or highlighted. One more advantage using vector data is the possibility of local processing, it is not necessary to contact the server per executed browser action. Disadvantages of vector data are manufacturer dependence as well as changing data volume because the amount of data can vary depending of the selected area. Transferring vector data may endanger the copyright of the owner of the original data, since with tricks a user could store the transferred data locally.

Basically the presentation at the client can be realised with vector as well as raster data. The choice of the transferring data form should consider the application and the existing infrastructure. Software products which offer optional transferring of vector or raster data may provide advantages. They may allow a preselection with raster data and afterwards loading of the actual vector data with the possibility of subsequently processing locally.

Different consortia develop future standard formats for transferring data over the Internet as shown in chapter 1. These formats probably will be used in near future.

2.4 An example for 3D visualisation of the terrain using VRML and Java

2.4.1 Basic idea

The Virtual reality modelling language VRML has been developed by the internet community and is a well known possibility to generate 3d worlds which can be used for walk throughs in common browsers extend by plug-ins which are available for free. More information on VRML and its usage are given in [Koppers, 1998]. In several projects we applied VRML. One prototype application was the 3D visualisation of the terrain.

The basic idea of the application is pretty easy and will be explained in this chapter.

Starting from different kinds of terrain related data (which could be included optionally) like:

➢ Digital Terrain Models (grid or TIN)

➢ Digital Map or GIS data (vector form)

➢ Aerial photographs, Remote sensing data (raster form)

we developed some procedures to integrate the different data and transform it more or less automatically to VRML format.

We have chosen VRML because of the following advantages:

➢ It is in principle platform independent

➢ It uses standard COTS software and it can be used over the Internet in principle

➢ The standard Internet Browsers (Netscape, Microsoft) can be extended – e.g. by cosmo player – to interpret VRML data. Using this extended Internet browsers one can e.g. view the terrain from various points of view, walk through the terrain, and use a couple of other navigation modes.

➢ This is a low cost solution because it runs on standard PC′s with cheap/free of charge software

That means only the data integration and transformation step has to be done to be able to generate a 3D model of the terrain, to view it and to walk through it.

But for serious applications there is one considerable disadvantages: this solution doesn't provide an orientation where the ′walker′ is in the terrain and in what direction he is looking. How we could get writ of this lack will be described next.

2.4.2 The application

To provide a georeferenced orientation for the ´walker´ we developed an application using Java language with extends the VRML browser mainly by an orientation window which displays additionally a map in which the position of the walker and his viewing direction is displayed.

The application includes the following components:

➢ The VRML window

➢ The orientation window which in general includes a topographical map. This map shows the position and the viewing direction of the ´walker´

➢ The navigation board to control the ´walker´

This application always provides a synchronisation of walk in the 3d world and the display of the actual position and viewing direction. This is obtained by a communication of the internet browser and the Java applet.

The application supports different navigation modes:

➢ Walk mode, allows for a walk through the scene (left, right, forward, backward with constant height)

➢ Slide mode, allows for an incline of the viewing direction

➢ Examine mode, allows for movement on a sphere surface

➢ Point mode. Allows the movement to a specific position

A more detailed discussion of the application can be found in [Koppers, 1998]

3   Potential of Internet/Intranet technology for GIS

As already mentioned Internet/Intranet technology offers quite a number of possibilities to open up new fields of applications for GIS or to improve existing applications considerably.

Internet technology was first used to establish so called map servers, where internet users could download maps (jpeg or GIF images) for example for tourism purposes. In a second step these maps have been connected to a information, for example the location of hotels or other points of interest, which could be visualised in the map. Furthermore results of complex analysis could be visualised using this technology. Please refer to [http://www.esri.com] for examples.

During the last years in several countries applications have been developed which allow for a distribution of geographic data via the internet. Figure 5 shows an example view from the USGS homepage. There interest people can download relevant geographic data [http://www.usgs.gov].
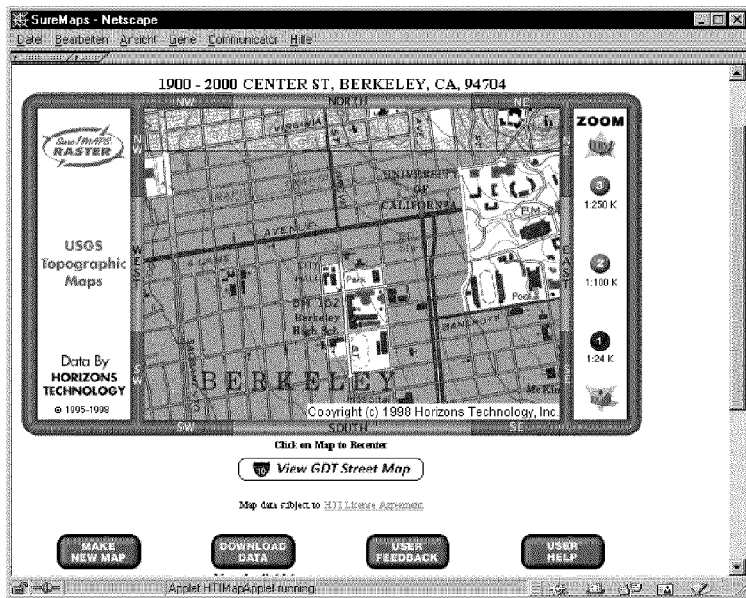
Figure 5: GIS and Internet example of USGS (screenshot)

Some of these application are using eCommerce techniques and products to allow for a more comfortable handling.

Implementations of Geographic Information Systems based on Internet/Intranet technology can be found in various fields and on very many places. In the following an example is presented which demonstrates how this techniques can be used in a meaningful manner.

This example comes from BASF enterprise (Fig. 6) and includes their main company site in Ludwigshafen / Germany which is larger than 7 km^2 and includes more than 2000 buildings, 115 km of roads and 211 km of railway tracks. The GIS application shall be used finally by the 20 000 Intranet users in Ludwigshafen and more than 10 000 Internet users world wide. All these people are just using a standard browser such as Internet Explorer or netscape communicator. Therefor the graphical data is transmitted in raster form (jpeg). It allows for queries for specific buildings, which can be searched by address and the result is presented alpha numerically and graphically. Furthermore queries concerning the location of roads / railroads under construction and closed roads are supported.

At some places such applications are used at the entrance of an enterprise to be able to produce specific maps for visitors with the route they have to follow to reach their destination on it.
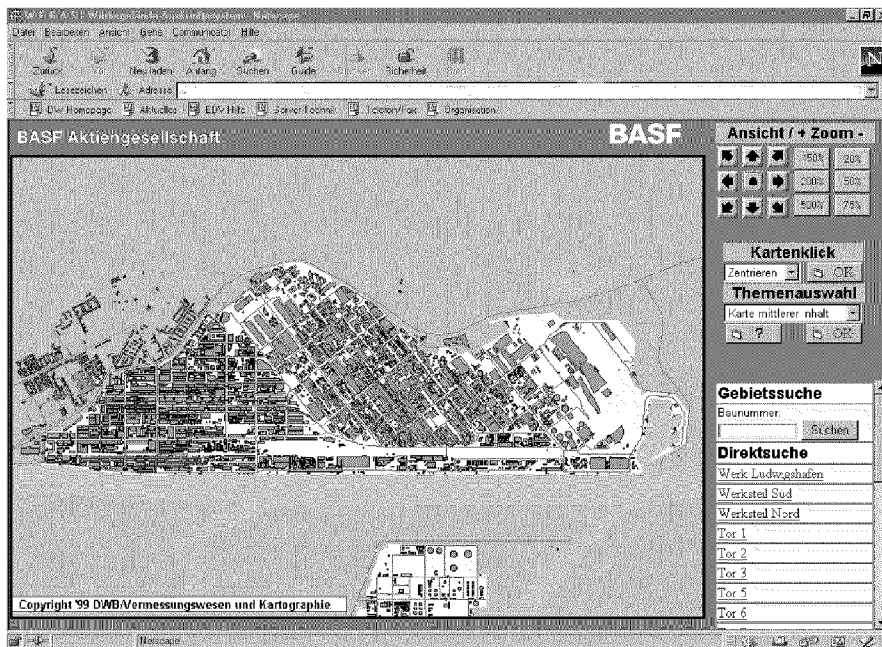
Figure 6: Screenshot from an example of an internet based GIS application

Recently there are also GIS based and Internet services available which can be used also from mobile phones and other mobile equipment (in combination with positioning equipment such as GPS) via the Wireless Application Protocol (WAP). Figure 7 shows the principle architecture of such applications. For details refer to the contributions in [Reinhardt, 2000] or to [http://www.mogid.com].

4   Conclusion

In this paper the principles of GIS and the Internet/Intranet technologies have been outlined. By some examples also the potential of this technology has been demonstrated. The main advantages of applications based on GIS and Internet/Intranet are:

- Internet / Intranet nowadays is a standard technology which is widely available and commonly used.
- Based on this technology applications can be provided which are easy to use also for non GIS experts.
- Via Internet or Intranet many users can access actual data stored in data servers.
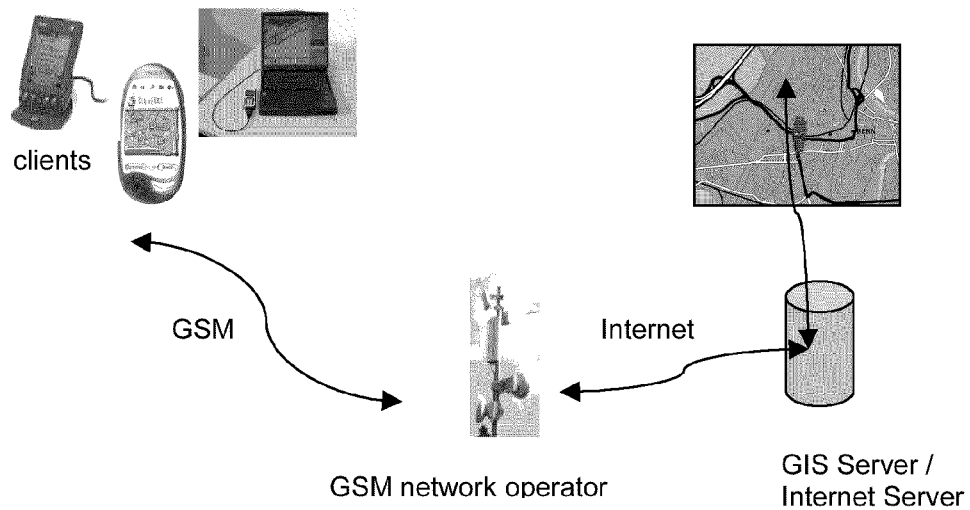- Information stored on different servers can be linked together easily using the hyperlink technique.

Figure 7: Principle architecture of GIS based mobile services

Literature

Assfalg, Goebels, Welter 1998: Internet Datenbanken - Konzepte, Methoden, Werkzeuge, Addison-Wesley

Koppers, 1998: 3D-Map - Virtual reality and Geodata, EOGEO '98, Salzburg

Leukert, K. and Reinhardt, W,: GIS Internet Architecture, Paper presented at the XV ISPRS Congress, Amsterdam 2000

Reinhardt, W. (editor), 2000: GIS and Internet/Intranet technology – proceedings of a seminar held at university FAF (in German)